

## *Starlight Xpress Ltd*

# *SXV-M8C 4 Megapixel USB2 One-Shot Colour CCD camera User manual*



**Thank you** for purchasing a Starlight Xpress CCD camera. We hope that you will be very satisfied with the results.

The SXV-M8C is an advanced, very high-resolution cooled CCD camera, especially designed for 'One-Shot' colour astronomical imaging. Its special features include a built-in, fully programmable, USB 2 super-fast computer interface (USB 1.1 compatible), an optional add-on autoguider output and integrated dual serial ports for filter wheel and telescope control. The SXV-M8C uses a Sony ICX406AQ 'SuperHAD' interline transfer CCD, with 2312 x 1720 x 3.125 $\mu$ m pixels in a 7.225 x 5.375mm active area. SuperHAD devices have excellent quantum efficiency, with a broad spectral response peaking at around 65% in the green, and an extremely low

dark current, well below that of any comparable CCD currently available. The ICX406AQ incorporates a 'Bayer Matrix' of Red, Green and Blue filters, deposited directly onto the CCD pixels and a downloaded image may be quickly converted into a full-colour picture by application of the software provided.

The full-frame download time is approximately 14 seconds and binned 4x4 downloads take only 3 seconds, so finding and centring are very quick and easy in this mode. If you have only a USB 1.1 connection on your computer, the download time is longer, but is still reasonable at around 25 seconds for a full resolution frame.

Please take a few minutes to study the contents of this manual, which will help you to get the camera into operation quickly and without problems. I am sure that you want to see some results as soon as possible, so please move on to the 'Quick Start' section, which follows. A more detailed description of imaging techniques will be found in a later part of this manual.

## **'Quick Starting' your SXV-M8C system**

In the shipping container you will find the following items:

- 1) The SXV-M8C camera head.
- 2) A power supply module.
- 3) A USB camera cable.
- 4) A guider cable
- 5) An adaptor for 1.25" drawtubes.
- 6) An adaptor for 2" drawtubes and M42 Pentax thread lenses.
- 7) A disk with the SXV-M8C control software and this manual.

Optional extra items include:

- 1) A serial port adaptor and cable.
- 2) An add-on guide camera head (includes a cable).

You will also need a PC computer with Windows 98, Windows Me, Windows 2000 or Windows XP installed (NOT Windows 95 or NT4). This machine must have at least one USB port available and at least 32 Megs of memory. If you intend to view the finished images on its screen, then you will also need a graphics card capable of displaying an image with a minimum of 1024 x 768 pixels in 24 bit colour. A medium specification Pentium with between 1000 and 3000MHz processor speed is satisfactory. USB 2 PCI cards are readily available for upgrading a USB 1.1 machine, if you want to achieve the best possible performance. Please note that USB 2.0 operates at a very high speed and cannot operate over very long cables. Five metres of good quality cable is the maximum normally possible. Adding one, or more, USB 2 'Hubs' in line can extend this, if necessary.

### **Installing the USB system:**

First, find a free USB socket on your PC and plug in the USB cable. If you do not have a USB capable computer, it is normally possible to install a USB 2 card into an

expansion slot. Almost all machines manufactured after 1996 provide a pair of USB 1.1 sockets on the rear panel and either of these may be used if USB 1.1 is satisfactory. Please note that it may be necessary to enable your USB system in the computer BIOS (the SETUP menu which can usually be accessed at start-up). Many BIOS systems have the ability to disable 'Plug and Play' devices, such as the USB ports, so please make sure that these are enabled.

The next operation is to run the USB installer from the CD ROM provided. Insert the CD into the computer and run the 'InstallSXV' file which is found in the SXV-M8C directory. This will install the following files:

- 1) 'SXVIO\_BlockIO\_M8C.inf' in C:\Windows\Inf\
- 2) 'Generic.sys' and 'SXVIO.sys' in C:\Windows\System32\Drivers\

If you cannot see the directories 'C:\Windows\Inf' and 'Windows\System32\Drivers', this will be due to the setup of your Windows Explorer software. In this case, go to the 'Tools' menu, followed by 'Folder Options' and select 'View'. Now select 'Show hidden files and folders' and make sure that the 'Hide file extensions for known file types' and 'Hide protected operating system files' check boxes are NOT checked. After this, the various directories and files should be visible.

It is now time to set up the USB device. Plug the USB cable into the camera and observe the computer screen. After a brief delay, you should see an information box, which reports that the computer is 'Installing a Starlight Xpress CCD camera'. If all is well, the cycle will complete within a couple of seconds, but it is possible that you may have to prompt the system with the location of the SXVIO.sys file (Windows\System32\Drivers). After another brief delay, the computer should say that it has found a new USB2.0 device and is installing a 'Starlight Xpress USB 2.0 SXV-M8C CCD camera'. In some cases the installation will halt after the first stage and you will need to restart the machine, or unplug and re-plug the USB lead to initiate the second step.

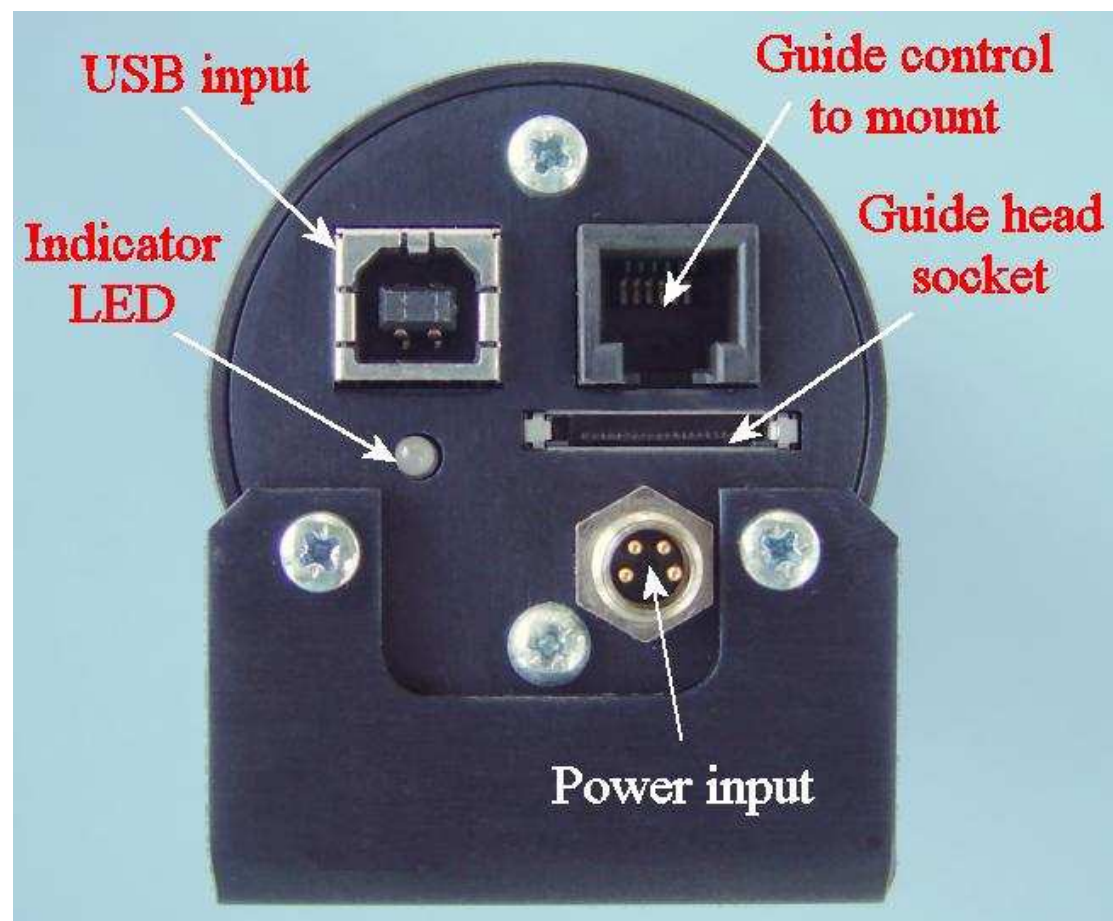


At the end of this process, the USB interface will be installed as an 'SXVIOClass device' and the camera software will be able to access it. You can confirm that the installation is complete by checking the status of the USB devices in the Windows 'Device Manager' (see above). Start up the Windows 'Control Panel' and select 'System'. Now click on the tab labelled 'Device Manager' and all of the system devices will be displayed in a list (see above). If the installation is successful, there will be a diamond shaped symbol labelled 'SXVIOClass' and clicking on the '+' sign will reveal it to be a 'Starlight Xpress USB 2.0 camera driver'. If this device is faulty, try clicking on it and selecting 'properties' and then 'update driver'. Following the on screen instructions will allow you to re-select the correct inf file (SXVIO.inf) and driver file (SXVIO.sys), which should fix the problem.

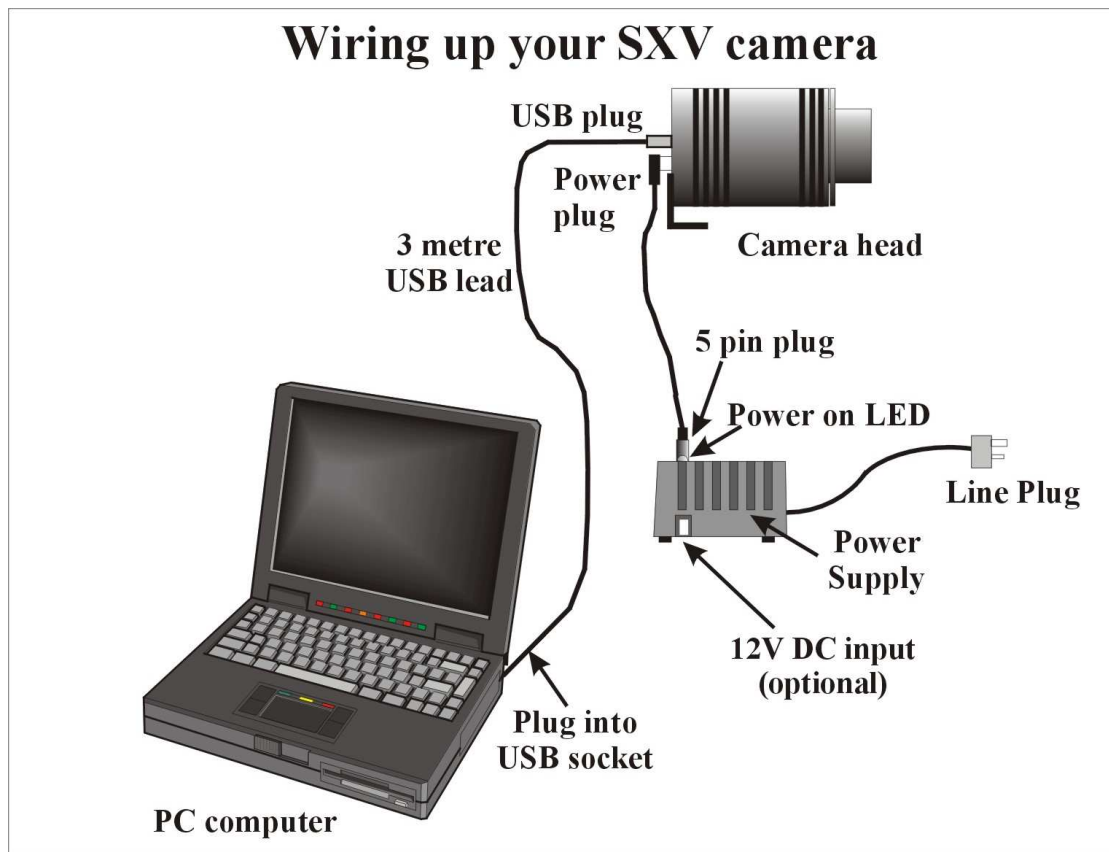
### **Adding the camera control software:**

Now that the USB system is installed, the camera control program can be used to operate your SXV-M8C. Copy the camera software files from the CD and paste them into a suitable directory, such as 'SXVH9' on your computer's C: drive. Your directory should contain the files SXV\_H9C.exe, SXV\_H9C.hlp, bwcc32.dll and wsc32.dll

### **Connecting the camera:**



**The camera rear panel**



Connect up the power supply and switch it on. You can start the 'SXV\_M8C' software by double clicking on the icon and you should see the main menu and image panel appear. If the USB connection is OK, a message box will inform you of the 'Handle' number for the SXVIO interface and various other version details etc. The main program window will now be seen.

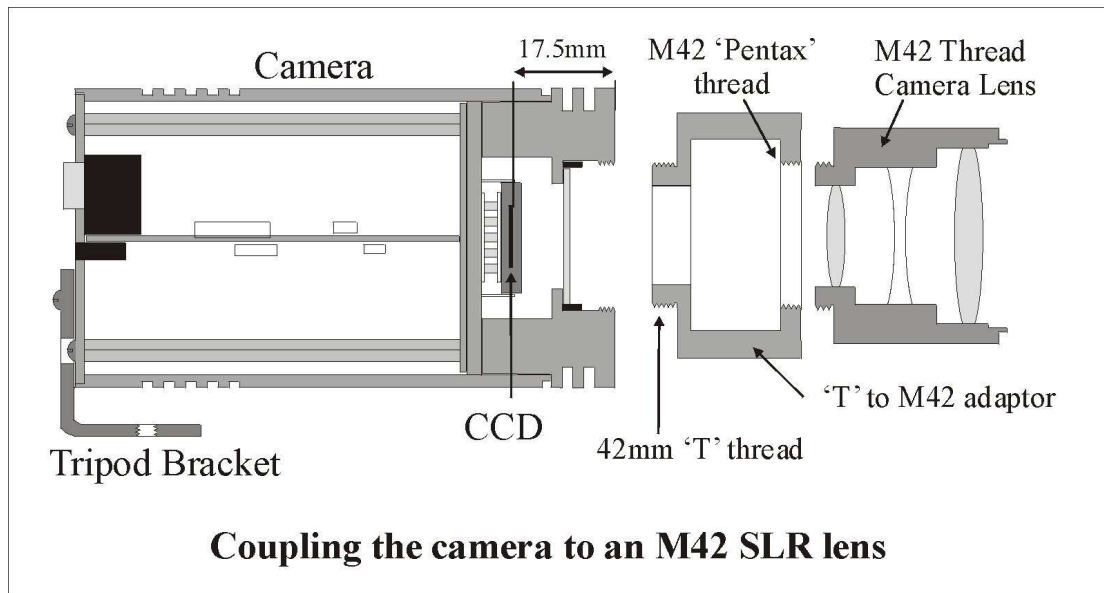
If you press the 'Camera' button at the top left, the program will warn you that the 'Program Defaults' have not been set, but pressing 'OK' will allow you to continue. The camera default settings are not important for current purposes and may be left as the software start-up values for now, but the warning message may be removed by selecting 'Set program defaults' from the 'File' menu and then saving the defaults window by pressing the 'Save changes' button. Once the camera control panel is seen, you are all set to take your first images!

### Recording your first image:

We now have the camera and computer set up to take pictures, but an optical system is needed to project an image onto the CCD surface. You could use your telescope, but this introduces additional complications, which are best avoided at this early stage. There are two simple options, at least one of which is available to everyone:

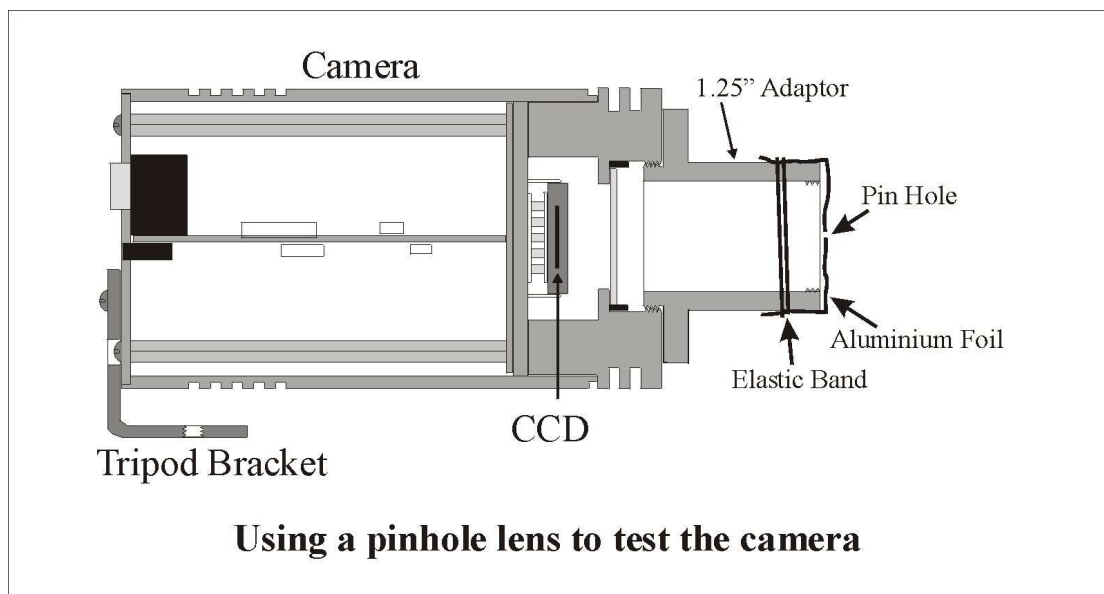
- 1) Attach a standard 'M42' SLR camera lens to the SXV-M8C, using the 25mm spacer to achieve the correct focal distance.





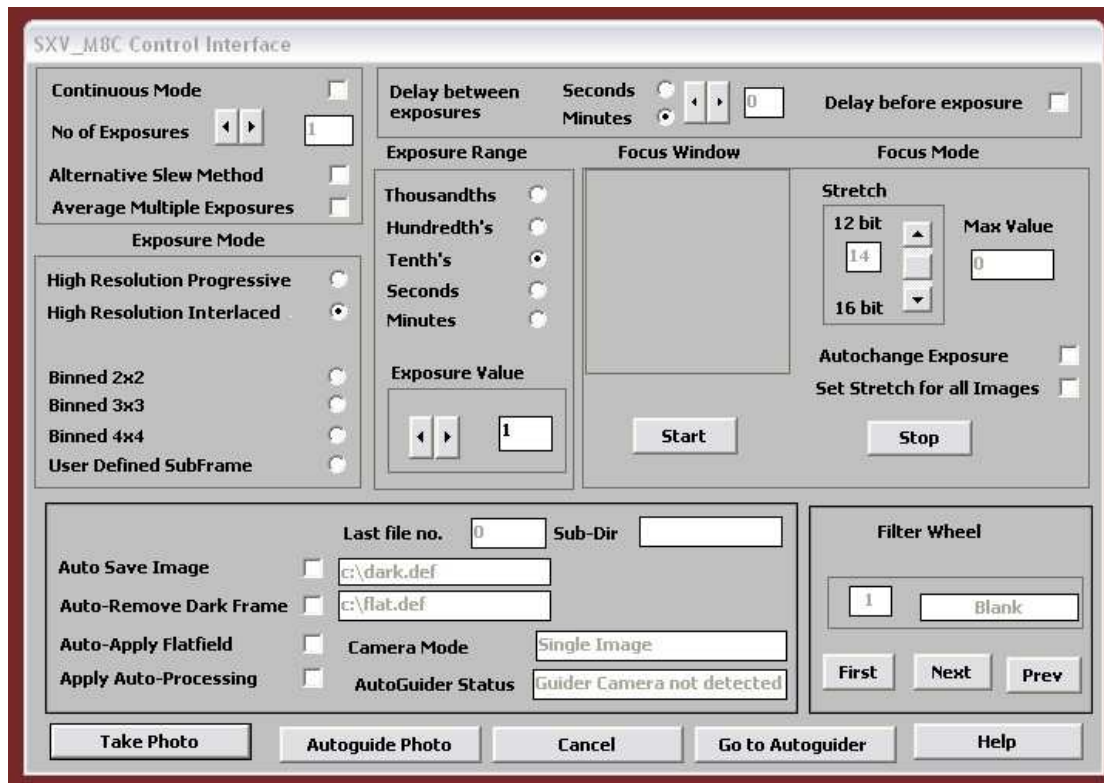
Or

- 2) Create a 'Pin hole' lens by sticking a sheet of aluminium baking foil over the end of the 1.25" adaptor and pricking its centre with a small pin.



If you use a normal lens, then stop it down to the smallest aperture number possible (usually F22) as this will minimise focus problems and keep the light level reasonable for daytime testing. The pin hole needs no such adjustments and will work immediately, although somewhat fuzzily.

Point the camera + lens or pinhole towards a well-lit and clearly defined object some distance away. Now enter the 'File' menu in the SXV\_M8C software and click on 'SXV-M8C camera interface' (or use the camera icon). Select an exposure time of 0.1 seconds, High Resolution Interlaced mode and press 'Take Photo'.



After the exposure and download have completed (about 14 seconds) an image of some kind will appear on the computer monitor. It will probably be poorly focused and incorrectly exposed, but any sort of image is better than none! In the case of the pinhole, all that you can experiment with is the exposure time, but a camera lens can be adjusted for good focus and so you might want to try this to judge the high image quality that it is possible to achieve. With our adaptor, most lenses come to infinity focus at about midway through their normal focus adjustment range.

Various other exposure options are available, as can be seen in the picture above. For example, you can 'Bin' the download 2x2, or more, to achieve greater sensitivity and faster download, or enable 'Continuous mode' to see a steady stream of images. The reason for the two 'High Resolution' modes (Progressive or Interlaced) is to enable both short and long exposures to be made in a format that can be colour converted. Progressive mode is ideal for use with relatively long 'deep sky' images (more than about 10 seconds), but will not work well for shorter exposures (daylight or planetary). Planetary shots are made in 'Interlaced' mode.

'Focus mode' downloads a 128 x 128 segment of the image at high speed. The initial position of the segment is central to the frame, but can be moved by selecting 'Focus frame centre' in the 'File' menu and clicking the desired point with the mouse. The focus window has an adjustable 'contrast stretch', controlled by the 12-16 bit slider. The image will be 'normal' if 16 bits is selected, while setting lower values will increase the image brightness in inverse proportion. Please note that ONLY 1x1 binned images will decode to colour – the other modes are for focusing and acquisition only.

*If you cannot record any kind of image, please check the following points:*

- 1) *Ensure that the power indicator lamp is on and that the cables are properly home in their sockets.*
- 2) *If the screen is completely white, the camera may be greatly overexposed. Try a shorter exposure time, or stop down your lens. See if covering the lens causes the image to darken.*
- 3) *If the USB did not initialise properly, the camera start-up screen will tell you that the connection is defective. Try switching off the power supply and unplugging the USB cable. Now turn the power supply on and plug in the USB cable. This will re-load the USB software and may fix the problem after restarting the SXV\_H9C program. Otherwise, check the device driver status, as previously described, and re-install any drivers which appear to be defective.*
- 4) *If you cannot find any way of making the camera work, please try using it with another computer. This will confirm that the camera is OK, or faulty, and you can then decide how to proceed. Our guarantee ensures that any electrical faults are corrected quickly and at no cost to the customer.*

### **Converting your image to colour:**

Once you have a recognisable image, it is quite easy to convert it to full colour. The 'raw' image will appear to have a fine grid distributed across it – this is the colour filter matrix and the variations of pixel brightness encode the colour data which we want to extract. Here is an enlarged section of a raw image:



Click on 'Colour Synthesis' in the main menu and you will see the synthesiser dialog.



SYNTHESIZE COLOUR IMAGE

Daylight Images need less Blue  
Can be useful for exposures over 5 minutes  
Apply Low Pass Filter to Colour data  
Recommended for all nighttime images  
Colour balance is affected by Infra red  
For Planetary images try weak stretch, for nebulae try strong.  
For Astro Images remove the background  
To crispen images use high pass filter, or an unsharp mask filter

Daylight Image?  
Light Pollution Correction  
Colour Smoothing Filter  
Apply Anti-Alias  
IR Filter Used?  

No Auto Stretch  
Apply Weak Stretch  
Apply Strong Stretch  
Auto Stretch - User

Remove Background  

High Pass Low Power  
Unsharp Mask  
dia. 3 power 1

Create Image Cancel Help

Nb: You can only convert to colour if the values of all three selection boxes are valid

This includes various options for correcting the colour synthesis for variations in the lighting conditions, filters etc. Briefly, these items perform the following functions:

- 1) **Daylight Image?** – If an unfiltered lens is used, the infra-red content of the light will tend to produce a Green – Blue shift in the balance. A partial correction of this bias is provided by selecting this option, but the best option is to use an infra-red blocking filter when taking daylight shots (see 5 below).
- 2) **Light Pollution Correction:** - This option is for deep sky colour images, where a strong colour bias is often present in the sky background. This option attempts to return the background colour to a neutral grey.
- 3) **Colour Smoothing Filter:** - Applies a low pass filter to the colour data to smooth out colour noise.
- 4) **Apply Anti-Alias:** - Runs a special filter over the colour data to remove coloured artefacts around sharp edges. This is especially useful for cleaning up erratically coloured star images.
- 5) **IR Filter Used?** – Sets the colour balance to allow for the loss of infra-red content when using an IR blocking filter.
- 6) **Stretching:** - A selection of contrast boosting options which are preset for various subjects.
- 7) **Remove Background:** - This option will adjust the sky background brightness to give an optimum background level.

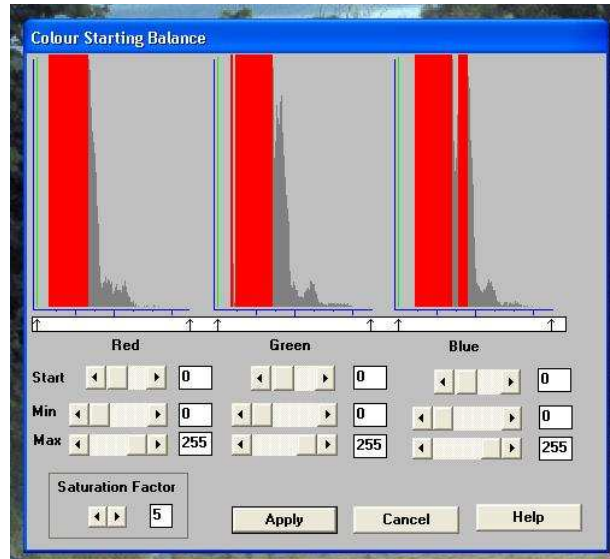
- 8) **High Pass filters:** - Automatically sharpen the luminance data to emphasise fine details. Most useful for sharpening planetary images but will also increase the noise content.

For your first test images, I suggest that you turn on the Anti-Alias option and possibly the 'Daylight Image' option.

Now press the 'Create Image' button. After a couple of seconds, your raw mono image will be replaced by a full colour version.



There is every reason to expect that the image will be reasonably well colour balanced, but if it is not, you can adjust the colour in the 'Set Colour Balance' dialog box (Under 'Colour' in the main menu).



The colour balance controls seem complex, but are really quite easy to use. The most useful controls are the 'Start' and 'Saturation Factor' settings. Saturation factor will simply vary the colour intensity, without any alteration of the colour balance, but the 'Start' settings for each colour will alter the colour rendering of the dimmer parts of the image. As most astronomical images are badly affected by light pollution, which affects the dimmer background colours in particular, the start point settings are particularly helpful for correcting this. If you move the start point of the Red histogram a few points to the right and click on 'Apply', the new image will have LESS red in the background and will appear more Cyan. Similarly, if you move the Green start point to the right, the image will appear more Magenta and moving the blue start point will turn it more Yellow. Do not move the start points beyond the start of the main burst of histogram data, or you will introduce colour errors into low saturation parts of the image. Just move the sliders by small amounts in the clear area below the main peak, until the background is nicely balanced.

In some cases, the histograms may all start a long way above zero (usually in astro. images with a lot of light pollution). In this case, slide the start point settings for all colours until they are equally distant from the beginning of the colour data, but quite close to it. This will both correct the colour balance (apart from any fine tweaks) and increase the colour saturation.

In some images, the colour data may be balanced differently in the highlights and shadows. For example, the dark areas may be quite neutral in colour, but the highlights may be bluish in tint. This indicates a 'slope error' in one or more colours and, in this example it is caused by the blue data increasing too quickly when compared with the red and green data. To correct for this, the other histogram sliders may be used as slope adjusters. In the case of the excess blue, try increasing the top end (Max) value to greater than 255 (300 max is allowed). This will reduce the blue slope and result in a more yellowish rendition.

### **Other image enhancements:**

Your first image may be satisfactory, but it is unlikely to be as clear and sharp as it could be. Improved focusing and exposure selection may correct these shortcomings, and you may like to try them before applying any image enhancement with the

software. However, there will come a point when you say, "That's the best that I can get" and you will want to experiment with the effects of image processing. In the case of daylight images, the processing options are many, but there are few that will improve the picture in a useful way. The most useful of these are the 'Normal Contrast Stretch' and the 'High Pass Low Power' filter. The high pass filter gives a moderate improvement in the image sharpness, and this can be very effective on daylight images.

Too much high pass filtering results in dark borders around well-defined features and will increase the noise in an image to unacceptable levels, but the Low Power filter is close to optimum and gives a nicely sharpened picture, as above.

The 'Contrast' routines are used to brighten (or dull) the image highlights and shadows. A 'Normal' stretch is a simple linear operation, where two pointers (the 'black' and 'white' limits) can be set at either side of the image histogram and used to define new start and end points. The image data is then mathematically modified so that any pixels that are to the left of the 'black' pointer are set to black and any pixels to the right of the 'white' pointer are set to white. The pixels with values between the pointers are modified to fit the new brightness distribution. Try experimenting with the pointer positions until the image has a pleasing brightness and 'crispness'. Most daylight pictures suffer from having too much 'Gamma' (a way of referring to the contrast response curve) and look unnaturally contrasty. Applying a 'Power law' stretch of about 0.5 power will often make them look better.

At this point, you will have a working knowledge of how to take and process an SXV-M8C image. It is time to move on to astronomical imaging, which has its own, unique, set of problems!

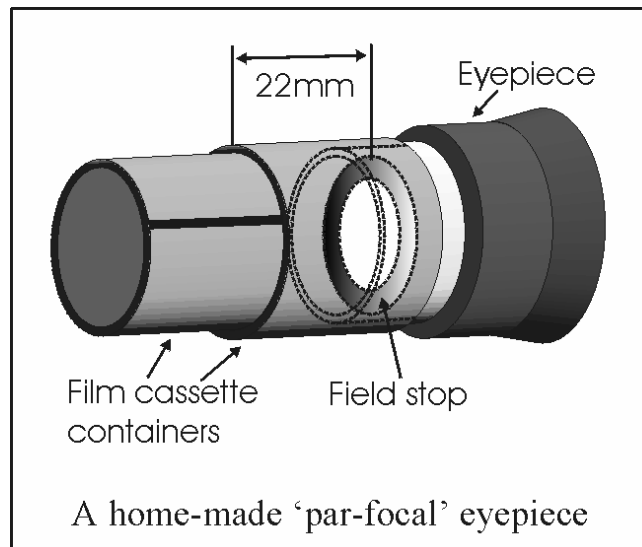
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## **Astronomical Imaging with the SXV-M8C**

### **1) Getting the image onto the CCD:**

It is fairly easy to find the correct focus setting for the camera when using a standard SLR lens, but quite a different matter when the SXV-M8C is attached to a telescope! The problem is that most telescopes have a large range of focus adjustment and the CCD needs to be quite close to the correct position before you can discern details well enough to optimise the focus setting. An additional complication is the need to add various accessories between the camera and telescope in order that the image scale is suitable for the subject being imaged and (sometimes) to include a 'flip mirror' finder unit for visual object location.

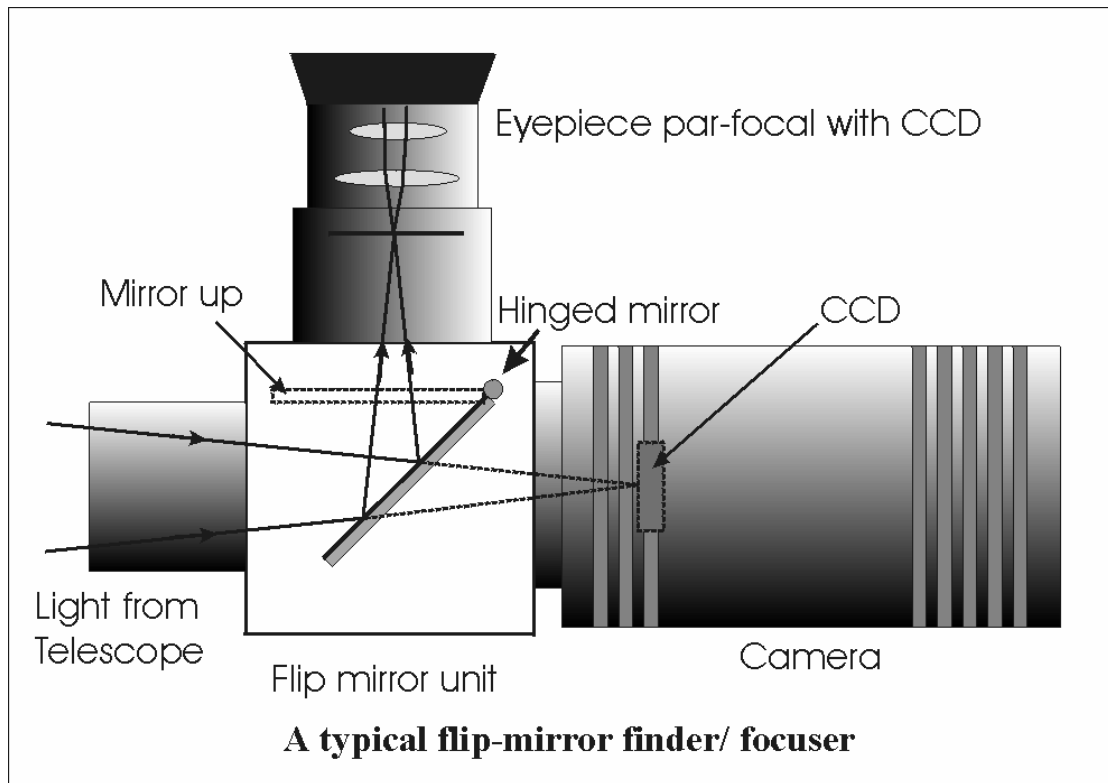
A simple, but invaluable device is the 'par-focal eyepiece'. This is an eyepiece in which the field stop is located at the same distance from the barrel end, as the CCD is from the camera barrel end.



When the par-focal eyepiece is fitted into the telescope drawtube, you can adjust the focus until the view is sharply defined and the object of interest is close to the field centre. On removing the eyepiece and fitting the CCD camera, the CCD will be very close to the focal plane of the telescope and should record the stars etc. well enough for the focus to be trimmed to its optimum setting

Several astronomical stores sell par-focal eyepieces, but you can also make your own with a minimum of materials and an unwanted Kellner or Plossl ocular. Just measure a distance of 22mm from the field stop of the eyepiece (equivalent to the CCD to adaptor flange distance of the camera) and make an extension tube to set the field stop at this distance from the drawtube end. Cut-down 35mm film cassette containers are a convenient diameter for making the spacer tube and may be split to adjust their diameter to fit the drawtube.

Another quite popular solution to the 'find and focus' problem is the 'flip mirror' unit. These operate on a similar principle to the single lens reflex camera, where a hinged mirror can drop into the light path and reflect the image through 90 degrees into a viewing eyepiece.



In this case, the camera and eyepiece are made par-focal with each other by locking up the mirror, focusing the camera on an easy object, such as a moderately bright star and then flipping the mirror down to view the same star with the eyepiece. Once the eyepiece has been locked into the correct position, you can use it to focus on the image by lowering the flip mirror and operating the telescope focus wheel until the image is sharp. When the mirror is raised, the image will fall onto the CCD surface and should be accurately in focus. Most flip mirror units allow several adjustments to be made, so that the image can be centred properly in the eyepiece and CCD fields, which are not necessarily coincident when you first buy your unit!

Opinions vary as to the utility of flip mirrors. They are a convenient way to find and focus, but they add quite a bit of extra length between the camera and telescope. This can be very inconvenient with Newtonians, and not a lot better with SCTs, especially if the assembly is somewhat flexible. They also make it difficult to use a focal reducer with your camera, as the rapidly converging light cone from a reducer cannot reach all the way through the flip mirror unit to the CCD surface. If you are using one of the popular F3.3 compressors for deep sky imaging, you will NOT be able to include a flip mirror unit in front of your camera and using a par-focal eyepiece is your best option.

Whichever device you use, it is necessary to set up a good optical match between your camera and the telescope. Most SCTs have a focal ratio of around F10, which is too high for most deep sky objects and too low for the planets! This problem is quite easy to overcome, if you have access to a focal reducer (for deep sky) and a Barlow lens for planetary work. The Meade F3.3 focal reducer is very useful for CCD imaging and I can recommend it from personal experience. It does not require a yellow filter for aberration correction, unlike some other designs, so it can also be used for tri-colour



imaging. If you use a focal reducer, do not try to use it at maximum reduction, as the large chip of the SXV-M8C will suffer from considerable ‘vignetting’ (dimming towards the corners) and this will be difficult to remove from your images. To achieve this, use only a short extension tube between the focal reducer lens and the camera. The longer the extension tube used, the greater the focal reduction will be. As a guide, most CCD astronomers try to maintain an image scale of about 2 arc seconds per pixel for deep sky images. This matches the telescope resolution to the CCD resolution and avoids ‘undersampling’ the image, which can result in square stars and other unwanted effects. To calculate the focal length required for this condition to exist, you can use the following simple equation:

$$F = \text{Pixel size} * 205920 / \text{Resolution (in arc seconds)}$$

In the case of the SXV-M8C and a 2 arc seconds per pixel resolution, we get

$$F = 0.00313 * 205920 / 2 = 324\text{mm}$$

For a 200mm SCT, this is an F ratio of  $324 / 200 = F1.6$ , which is only possible with something like the ‘Fastar’ adaptor. Hence images with normal SCT optics are going to be considerably ‘oversampled’. This can often be acceptable, but it is clear that the SXV-M8C is better suited to small refractors and lenses than long focus SCT telescopes.

The same equation can be used to calculate the amplification required for good planetary images. However, in this case, the shorter exposures allow us to assume a much better telescope resolution and 0.25 arc seconds per pixel is a good value to use. The calculation now gives the following result:

$$F = 0.00313 * 205920 / 0.25 = 2578\text{mm}$$

This is approximately F13 when used with a 200mm SCT and so we could use the native F10 focal length with good results. A Barlow lens can be used to increase the image scale, if necessary.

### **Achieving a good focus:**

Your starting point will depend on the focus aids, if any, which you are using. With the par-focal eyepiece, you should slip the eyepiece into the drawtube and focus visually on a moderately bright star (about 3<sup>rd</sup> magnitude). Now withdraw the eyepiece and carefully insert the camera nosepiece, until it is bottomed against the drawtube end, and then lock it in place.

With the flip mirror unit, all that is needed is to swing the mirror down and adjust the focus until the star is sharply defined and centred in the viewing eyepiece. Now lift the mirror and you are ready to start imaging.

SXV\_M8C has a focus routine that will repeatedly download and display a 128 x 128 pixel segment of the image at relatively high speed. This focus window may be positioned anywhere in the camera field and can be displayed with an adjustable degree of automatic contrast stretching (for focusing on faint stars). To use this mode,

start up the software and select the SXV camera interface (File menu). Set the camera mode to Binned 1x1 and select an exposure time of 1 second. Press 'Take Picture' and wait for the image to download. There is a good chance that your selected star will appear somewhere within the image frame and it should be close to a sharp focus. If the focus is still poor, then it may appear as a pale disk of light, often with a dark centre (the secondary mirror shadow in an SCT, or Newtonian). Now select the 'File' menu again and click on 'Focus frame centre'; you can now use the mouse pointer to click on the star image and the new focus frame co-ordinates will be displayed. Now return to the camera interface window and click on 'Start' in the Focus frame. The computer will now display a continuous series of 128 x 128 pixel images in the focus window and you should see your selected star appear somewhere close to the centre. A 'peak value' (the value of the brightest pixel) will also be shown in the adjacent text box and this can be used as an indication of the focus accuracy. Although the peak value is sensitive to vibration and seeing, it tends towards a maximum as the focus is optimised. Carefully adjust the focus control on your telescope until the image is as sharp as possible and the peak value reaches a maximum. Wait for any vibration to die down before accepting the reading as reliable and watch out for bursts of bad seeing, which reduce the apparent focus quality. Quite often, the peak value will increase to the point where it is 'off scale' at 4095 and in this case you must halt the focus sequence and select a shorter exposure if you wish to use the peak value as an indicator. Once you are happy with the focus quality achieved, you might like to trim the settings of your par-focal or flip mirror eyepiece to match the current camera position.

Although you can reach a good focus by the above method, many observers prefer to use additional aids, such as Hartmann masks (an objective cover with two or three spaced holes) or diffraction bars (narrow parallel rods across the telescope aperture). These make the point of precise focus easier to determine by creating 'double images' or bright diffraction spikes around stars, which merge at the setting of exact focus. The 12-16 bit slider control allows you to adjust the contrast of the focus frame for best visibility of the star image. It defaults to maximum stretch (12 bits), which is generally ideal for stars, but a lower stretch value is better for focusing on planets.

### **Taking your first astronomical image:**

I will assume that you are now set up with a focused camera attached to a telescope with an operating sidereal drive. If so, you are now in a position to take a moderately long exposure of some interesting deep-sky astronomical object (I will deal with planets later). As most drives are not very accurate beyond a minute or two of exposure time, I suggest that you find a fairly bright object to image, such as M42, M13, M27 or M57. There are many others to choose from, but these are good examples.

Use the finder to align on your chosen object and then centre accurately by using the focus frame and a short exposure of between 1 and 5 seconds. The '12-16 bit' slider in the focus frame allows you to adjust the image contrast if you find that the object is too faint with a short exposure. Once properly centred and focused, take an exposure of about 60 seconds in 'Progressive' mode, and observe the result. Initially, the image may appear rather barren and show only a few stars, however, there is a great deal of data hidden from view. You can get to see a lot of this, without affecting the image data, if you go to the 'View' menu and select 'Auto Contrast Stretch Image'. The faint

image data will then appear in considerable detail and I think that you will be impressed by the result!

If you are happy with the image, go to the 'File' menu and save it as a FIT file in a convenient directory.

Most competitive brands of CCD camera require a 'dark frame' to be subtracted from your images to achieve the best results. A dark frame is simply a picture which was taken with the same exposure as your 'light frame', but with the telescope objective covered, so that no light can enter. It records only the 'hot pixels' and thermal gradients of your CCD, so that these defects are largely removed when the dark frame is subtracted from the light frame. The SXV-M8C CCD is quite different from those used in other brands of camera and generates an extremely low level of dark noise. Indeed, it is so low that subtracting a dark frame can actually INCREASE the noise in your images! This is because the statistical noise of the dark frame can exceed the 'pattern noise' from warm pixels and hence add to that of the subtracted result. If your test pictures have an exposure time of less than about 10 minutes (as above), then don't bother with a dark frame, just 'kill' any hot pixels with your processing software. In SXV-M8C, the 'Median filter' can do this, but other software (e.g. Maxim DL) will provide a 'hot pixel killer' that can be mapped to specific locations in the image.

If you feel that dark frame really is necessary, please proceed as follows:

To take a dark frame, just cover the telescope objective with the lens cap, or drop the flip mirror to block the light path to the CCD (make sure that this is light tight), and take another exposure of the same length as that of the light frame. This image will be a picture of the dark signal generated during your exposure and it should be saved with your image for use in processing the picture. If many such darks are recorded and averaged together, the statistical noise will be reduced, but the gains to be had are rather small compared with the effort involved.

As variations in ambient temperature will affect the dark signal, it is best to take the dark frames within a few minutes of capturing your images. For the same reason, it is not wise to use 'old' dark frames if you want the best possible results, however, some software allows you to scale library dark frames to match the image (e.g. AstroArt) and this can be useful as a time saver.

'Flat fields' are often recommended for optimising the results from your CCD camera, but these are generally less important than dark frames, especially if you make sure that the optical window of the camera is kept dust-free. The purpose of a flat field is to compensate for uneven illumination and sensitivity of the CCD and it is better to avoid the need for one by keeping the optics clean and unvignetted. I will ignore flat fielding for current purposes and describe the process in detail at a later stage.

### **Processing a deep-sky image:**

The following instructions include the subtraction of a dark frame, but this may be regarded as optional.



1) Make sure the 'Auto Contrast Stretch' is switched off and load your image into the SXV\_M8C program. Select 'Merge' and then 'Subtract Dark Frame'. Pick the appropriate dark frame and the software will then remove the dark signal from your image, leaving it somewhat darker and slightly smoother than before.

2) The next step is to process the image into colour, but you may find that the application of a gentle contrast stretch to the image before synthesis will improve the colour result. Don't overdo the stretch, as the colour range can then exceed the dynamic range available, leading to uncorrectable colour errors. Make sure that you keep a copy of the original file – just in case! Set the colour synthesiser to apply the anti-alias filter and then run it.

3) The resulting image will probably still look faint and dull, with a pale orange or green background due to light pollution. Try using the 'Start point' adjustment in the Colour balance menu to get something close to a neutral background colour. Moving up the red and green start points will reduce the light pollution tint in the background. It is now time to process the 'luminance' (brightness and contrast) of the image to get the best visual appearance. First, use the 'Normal' contrast stretch to darken the background by setting the 'Black' slider just below the main peak of the histogram. Alternatively, you can use the 'Remove Background' option to let the software decide on the best setting. This will greatly reduce the background brightness and the image will begin to look rather more attractive, if dark. You can now try brightening the highlights with another 'Normal' stretch, in which you bring down the 'White' slider to just above the main image peak. The best setting for this is rather more difficult to guess and you may need several attempts before the result is ideal. Just use the 'Undo last filter' function, if necessary, to correct a mistake. In many cases, a 'Normal' contrast stretch will give a good result, but may 'burn out' the bright regions and leave the faint parts of the image rather lacking in brightness. To combat this, many

imagers will use a combination of 'Normal' and 'Non-linear' contrast stretches. The best settings are different for different objects, but performing a non-linear or power law stretch, followed by normalising the background to black with a normal stretch, is the usual procedure.

- 5) The image will now look quite impressive and I hope that you are pleased with your first efforts!



M27 from a 15 minute exposure at F5 with a C11

Further small refinements are usually possible and you will become expert at judging the best way to achieve these as your experience increases. As a rough guide, the 'Filters' menu can be used to sharpen, soften or noise reduce the image. Strong 'High Pass' filters are usually not a good idea with deep sky images, as the noise will be strongly increased and dark rings will appear around the stars, but a 'Median' filter can remove odd speckles (hot pixels) and a mild 'Unsharp Mask' (Radius 3, Power 1) will sharpen without too much increase in noise.

Other things to try include summing several images for a better signal to noise ratio. This **MUST** be done **AFTER** colour synthesis, as summing raw images is highly likely to destroy the filter grid pattern and so prevent the creation of a proper colour image. Summing can be done in the 'Merge' menu and involves loading the first processed image, selecting a reference point (a star) then loading the second image and finding the same star with the mouse. Once the reference is selected, you can either add directly, or average the images together. Averaging is generally better, as you are less likely to saturate the highlights of the picture. The signal-to-noise ratio will improve at a rate proportional to the square root of the number of summations

(summing 4 images will double the signal-to-noise), but **different** exposures must be used. Summing an image with itself will not change the S/N ratio!

Although I have concentrated on the use of a telescope for deep-sky imaging, do not forget that you have the option of using an ordinary camera lens for impressive wide-field shots! A good quality 135 or 200mm F3.5 lens with an infrared blocking filter and a 'minus violet' filter will yield very nice images of large objects, such as M31, M42, M45 etc. If you cannot obtain a large IR blocker for the front of the lens, it is quite acceptable to place a small one behind the lens, inside the adaptor tube. You can also try using a light pollution filter to bring out nebulae, reduce light pollution and sharpen the star images. The Hutech/IDAS P2 type is particularly effective with a colour camera.

### **Taking pictures of the planets:**

Planetary imaging is in many ways quite different from deep sky imaging. Most deep sky objects are faint and relatively large, so a short focal length and a long exposure are needed, while planets are bright and very small, needing long focal lengths and short exposures. High resolution is critical to achieving good results and I have already shown how a suitable focal length can be calculated and produced, if necessary, by using a Barlow lens. Planetary images are taken in High Resolution Interlaced mode.

Many camera users comment on the difficulty of finding the correct focus when taking pictures of Jupiter etc. This is usually due to poor seeing conditions, which are only too common, but may also be due in part to poor collimation of your telescope. Please ensure that the optics are properly aligned as shown by star testing, or by using one of the patent collimation aids that are widely available. It is also better to use a star for initial focusing, as planetary detail is difficult to judge in bad seeing. Although the star will also suffer from blurring, the eye can more easily judge when the most compact blur has been achieved!

You could begin by imaging lunar craters, or the planets, Jupiter, Saturn or Mars. The rapid variations of seeing which accompany planetary imaging will ruin the definition of about 95% of your images and so I recommend setting the camera to run in 'Autosave' mode. This will automatically take a sequence of images and save them with sequential file names in your 'Autosave' directory. Dozens of images will be saved, but only one or two will be satisfactory for further processing. The 'Subframe' mode of the SXV may be found useful for limiting the wasted area and reducing the download time of small planetary images.

To start the Autosave process, call up the SXV Camera Interface and select the 'Continuous Mode' check box at the top (make sure the rest are unchecked). Now check the 'Autosave Image' checkbox near the bottom of the window. If you now click on 'Take Picture' the automatic sequence will begin and will not stop until you press a computer key. The images will be saved in FITs format with sequential names such as 'Img23, Img24....' and will be found in the 'Autosave' directory (or a sub-directory of Autosave, set up in the program defaults menu).



The exposure time needed for good planetary images is such that the image histogram has a peak value at around 200 and does not extend much above 220 (Ignore the major peak near zero, due to the dark background). If you use too short an exposure time, the image noise level will be increased, and if too long a time is used you will saturate the highlights and cause white patches on the image. With the recommended focal length, Jupiter and Mars will both need an exposure time of between 0.1 and 1 seconds and Saturn will need between 0.5 and 2 seconds.

### **Processing a planetary image:**

Planetary images have one major advantage over deep sky images, when you come to process them – they are MUCH brighter, with a correspondingly better signal to noise ratio. This means that aggressive sharpening filters may be used without making the result look very noisy and so some of the effects of poor seeing can be neutralised. Try applying an ‘Unsharp Mask’ filter with a radius of 5 and a power of 5. This will greatly increase the visibility of any detail on the planet, but the optimum radius and power will have to be determined by experiment.



Jupiter after an ‘Unsharp mask’

In general terms, the larger the image and the worse the seeing, then the wider the radius for best results. My Jupiter shots are usually about one third the height of the CCD frame and I find that the ‘radius 5, power 5’ values are good for most average seeing conditions. If you have exceptionally good conditions, then a reduction to R=3, P=3 will probably give a more natural look to the image, as too large a radius and power tends to outline edges with dark or bright borders.

As a finishing touch, the application of a Median filter or a Weighted Mean Low Pass filter can be useful to smooth out the high frequency noise after a strong Unsharp Mask.

As with deep-sky images, it is advantageous to sum colour planetary images together to improve the signal to noise ratio. In this case, the ‘averaging’ option should always be used, or the result is likely to exceed the dynamic range of the software and saturate the highlights. Aligning the images is always something of a problem, as

there are rarely any stars to use when imaging the planets, but Jupiter's satellites can be useful reference points. Otherwise, you will have to find a well-defined feature on the planet, or estimate where the centre of the disk is located. Some more sophisticated software can automatically align planetary images and you may find these programs to be very useful.

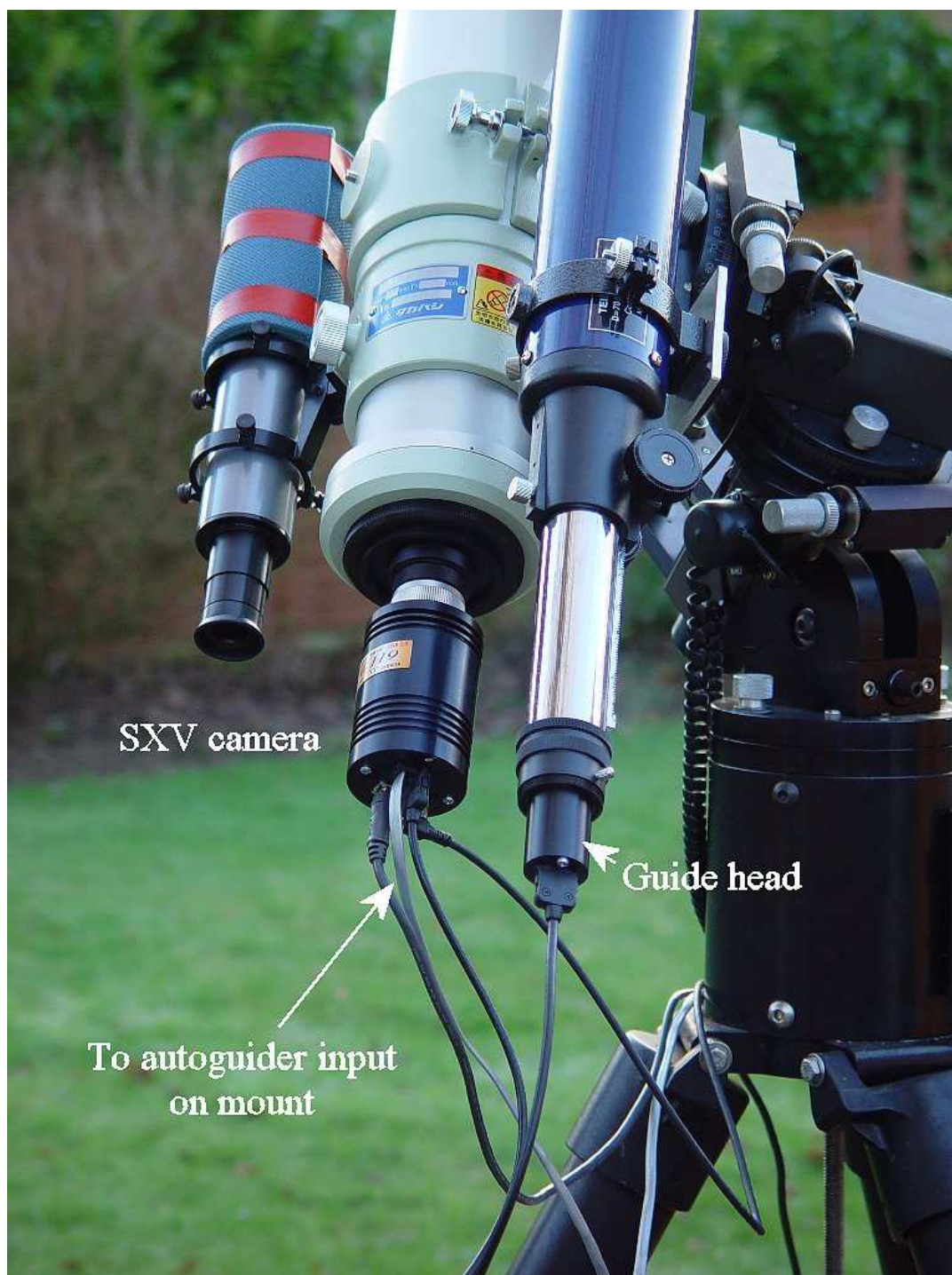
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### **Using the add-on autoguider:**

A very useful accessory is the add-on autoguider head, which takes its power and control signals directly from the SXV camera, via the 18 way socket on its rear panel. The autoguider is only 1.25" in diameter and has a video style 'CS' mount thread in its nose, so video lenses may be attached. The guider may be used with either an off-axis prism assembly mounted in front of the SXV camera, or with a separate guide telescope, rigidly mounted alongside your imaging telescope. I personally use it with a 70mm aperture, F12, inexpensive refractor as a guide 'scope, but a shorter focal length lens will make more guide stars available in any given region of sky (See the picture below).

To use the autoguider, first orient it so that the connector plug is roughly parallel to the declination axis of your mount. This is not absolutely essential, as the training routine will learn the angle of the head and compensate for it, but it is easier to understand the motion of the guide star if the guider frame is aligned with the RA and Dec axes. Now connect the head to the SXV camera, using the 18 way connector lead, including the port divider box, if it is to be used.

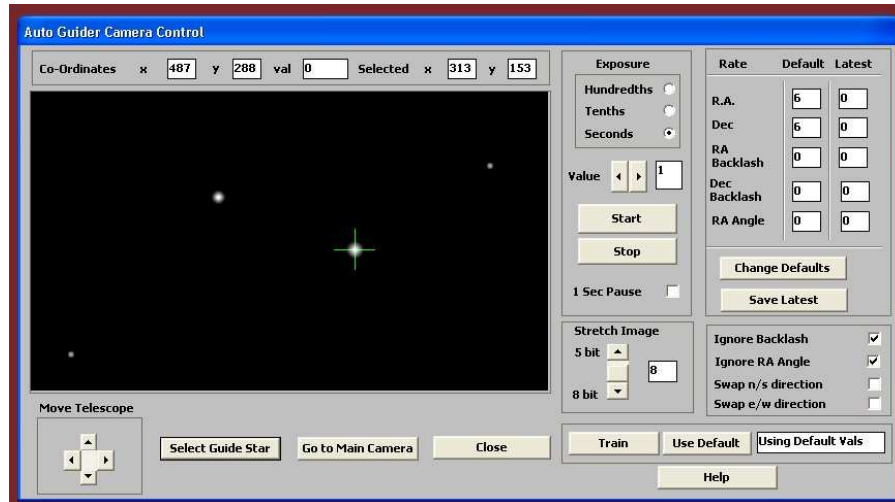
The recommended way of connecting the autoguider output to the mount is to use an RJ11 telephone lead between the socket on the SXV camera and the autoguider input of your mount. This output is 'active low' (i.e. the control relays pull the guider inputs down to zero volts when applying a guide correction) and matches most of the autoguider inputs on commercial mounts. If 'active high' inputs are needed, or a very low control voltage drop is essential, then you will need to add a Starlight Xpress 'relay box' between the guider output and the input to the mount. Please contact your local distributor if a relay box is required. Some mounts (Vixen, for example) use a similar guider input socket, but have re-arranged connections. Details are given on our web pages at the end of the 'STAR2000' section.



The autoguider installed on a 70mm refractor guide 'scope in the author's garden

To use the autoguider, please proceed as follows:

- 1) Having started the SXV-M8C software, open the autoguider control panel by clicking on the autoguider menu button.



The autoguider control panel with a guide star selected

- 2) Press the 'Start' button and a series of 1 second exposure guider images will begin to appear in the picture frame. If the images look too dim, use the 'Stretch Image' slider to increase its contrast and brightness until the noise begins to be visible.
- 3) If you haven't focused the guider lens or 'scope, move the mount until a bright star is visible on the guider image and then adjust the focus until it is as sharp as possible.
- 4) At this point, you may want to test the guiding control by pressing the manual 'Move Telescope' buttons at the bottom left corner of the control panel. You can watch the position of any stars in the guider image and confirm that they move in response to the buttons. The movement should be slow if the correct guiding rate is selected on your mount (typically 2x sidereal). Adjust this, if necessary.
- 5) Move the mount until the required object for imaging is properly framed in the main CCD image (leave the guider menu and use the main camera control panel, as necessary).
- 6) Re-open the guider control panel, start imaging and try to locate a clearly visible guide star. If necessary, make adjustments to the guide telescope or off-axis guider until one is found.
- 7) Press 'Stop' and then press 'Select Guide Star'. Use the mouse to left click on the selected star and a green cross will highlight it and the co-ordinates will appear in the text boxes above the image window.
- 8) The various guiding rate defaults, listed on the right-hand side of the control panel, are unlikely to be perfect for your particular telescope and mount. You have the option of manually selecting values, or asking the software to attempt to determine what they should be. This is done by pressing the 'Train' button and waiting for the software to complete a sequence of automatic moves and

calculations. The training will also determine the angle at which the guide camera is oriented with respect to the RA and Dec axes. If you do not wish to train the system at this time, the default values of 6 pixels per second will serve as a starting point.

- 9) Now press 'Go to main camera' and the guider control panel will be replaced by the camera control panel. Set the required exposure time for the image (say 5 minutes) and press the 'Autoguide next image' button. The autoguider window will reappear and, after a few seconds, you should see error values appearing in the text windows at the top. The guide star will be fairly close to the green cross, although not necessarily accurately centred, and you should see the power/ guide LED on the rear of the camera brighten and change colour with each correction.
- 10) If the star begins to drift away from the cross, despite the corrections being made, the chances are that the N/S and/or E/W directions are set wrongly. Judge which axis is incorrectly set by observing the direction of the drift and then stop the exposure by pressing 'Esc'. Open the guider control panel and check the appropriate swap box(es). After this operation, you will probably need to find the guide star again by taking a guider image and reselecting the star, as before. Now return to the main camera menu and try the 'Autoguide next image' button again.
- 11) Once guiding is taking place without problems, the main exposure can be allowed to finish and, if all is well, you should see an image with tiny circular stars.

If the stars are not circular, you may need to alter the guiding parameters, or investigate the rigidity and drive performance of your mount. A lot of information can be deduced by watching the behaviour of the guide star in the guider frame. If it is continually moving between two locations, either side of the green cross, then the RA or Dec pixels per second value is set too low. The higher these values are set, the gentler the guiding becomes. Too low a value will cause an over-aggressive correction to be made and result in oscillation of the star position between two points.

Another source of guiding errors can be a too accurately balanced telescope mount! Good balance can result in the telescope mount 'bouncing' between the gear teeth as corrections are made. A simple fix is to add a weight of about 0.5kg (1 pound) on the eastern end of the declination axis, so that there is always some pressure acting against the gear teeth.

Getting a good result from an autoguider will often entail a lot of detective work to eliminate the sources of gear error, telescope flexure, mirror shift etc., but the final result is well worth the effort!

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### Using the built-in serial ports

The SXV-M8C incorporates two fast serial ports for use with external accessories. The ports are available on 5 pins of the 18 way connector that is provided for the autoguider and may be accessed by plugging in a 'serial port divider box'. The divider

box and cables are available as an accessory and may be chained in series with the autoguider cable, when the guider is in use, or may be used on its own.

The two serial connections are in the form of standard RS232 PC style plugs and provide TX, RX and Ground connections at RS232 levels. Access is via commands sent through the USB connection and, at the time of writing, is limited to any serial controls that are provided by the SXV software. It is expected that many more functions will be added as the software is upgraded.

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## **Other features of the SXV-M8C hardware and software**

### **‘Slew & Sum’ imaging:**

The SXV-M8C can be used in an automatic image-stacking mode, called ‘Slew & Sum’. The camera is set to take several sequential exposures, which are automatically ‘slewed’ into alignment and then summed together by the software. This mode can help to overcome a poor RA drive by summing images that have exposure times shorter than the drive error period. The resulting image has more noise than a single exposure of the same total length, but this method of imaging is still an effective way of making long exposures without a guider.

To take an S&S image, go to the camera interface window and select an exposure time for one image of the sequence. Do not use a very short exposure time, as the read-out noise will become dominant. About 30 seconds is a reasonable minimum. Now go to the ‘Multiple Exposure Options’ and select a number of exposures to take. You can also select to average the images, rather than adding them, and there is a ‘Alternative Slew Mode’ available, which uses the correlation of image areas, rather than a single star. This mode can be better in dense star fields.

Another option is ‘Auto remove dark frame’. This is advisable with S&S images, as the slewing will mis-register the images with a single dark frame that is applied to the finished sequence. To use this option, you will need a dark frame, taken with the same exposure time as a single image from the sequence. This is stored on drive C with the name ‘dark.def’

Now click on ‘Take Picture’ and the sequence will begin.

### **Using the ‘Binned’ modes:**

Up to this point, I have assumed that the full resolution, imaging mode is being used. This is essential for colour imaging, but it will often provide more resolution than the optical system, or the seeing, allows. ‘Binned 2x2’ mode sums groups of 4 pixels into one output pixel, thus creating a 1156 x 860 pixel image with 4 times the effective sensitivity. Using 2x2 binning, you can considerably improve the sensitivity of the SXV-M8C without losing a great deal of resolving power, so you may like to use this mode to capture many faint deep-sky objects in monochrome. Other binning modes (3x3 and 4x4) are available and will further increase the image brightness and reduce



its resolution. However, generally, these are more useful for finding faint objects, than for imaging, as the colour information is lost in all these modes.

### **Taking and using a flat field:**

Flat fields are images, which display only the variations of illumination and sensitivity of the CCD and are used to mathematically modify a wanted image in such a way that the errors are removed. Common flat field errors are due to dust motes on the camera window and vignetting effects in the optical system of the telescope. Dust motes act as 'inverse pinholes' and cast out-of-focus images of the telescope aperture onto the CCD chip, where they appear as shadow 'do-nuts'. Most optical systems show some vignetting at the edges of the field, especially when focal reducers are used. This causes a brighter centre to show in images, especially when there is a lot of sky light to illuminate the field.

If dust motes are your main problem, it is best to clean the camera window, rather than to rely on a flat field to remove the do-nuts. Flat fields always increase the noise in an image and so physical dust removal is the best option. If you have serious vignetting, first check whether the optical system can be improved. The most likely cause of this problem is trying to use too powerful a degree of optical compression with a focal reducer and you might want to try moving the camera closer to the reducer lens.

If you really do need to use a flat field for image correction, then it must be taken with care. It is most important that the optical system **MUST NOT** be disturbed between taking your original images and taking the flat field. Any relative changes of focus and rotation etc. will upset the match between flat field and image and the result will be poor correction of the errors. The other necessity for recording a good flat field is a source of very even illumination of the telescope field and good colour matching of the light source to the sky light. This is surprisingly difficult to achieve and many designs of light source have appeared in the literature and on the Web. These usually consist of a large wooden box, containing several lamps and an internal coating of matt white paint, which is placed over the objective of the telescope to provide an evenly illuminated surface. These can work well, but I prefer a simpler method, as follows:

Most imaging sessions begin or end in twilight and so the dusk or dawn sky can provide a distributed source of light for a flat field. However, using the sky directly is likely to result in recording many unwanted stars, or patches of cloud etc., so a diffuser needs to be added to the telescope. An ideal material is Mylar plastic drafting film, obtained from an office supplies warehouse. It is strong and water resistant and can be easily replaced if damaged. Stretch a piece of the film loosely across the aperture of your telescope and point the instrument high in the sky, to avoid any gradient in the light near the horizon. Now take several images with exposure times adjusted to give a bright, but not overloaded, picture. A histogram peaking at around 128 is ideal. Averaging flat fields together is a good way to reduce their noise contribution and so recording 4, or more, images is a good idea.

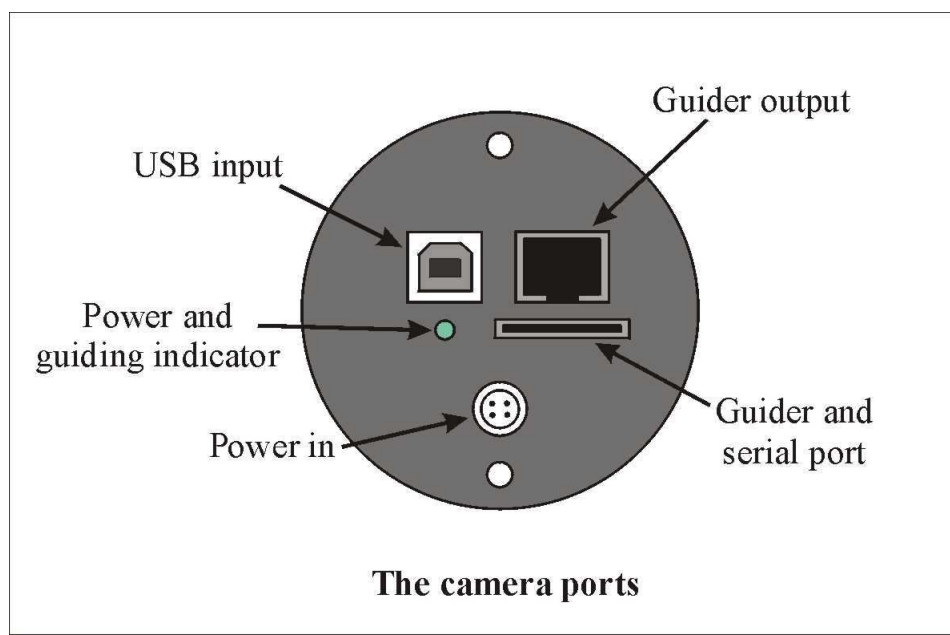
To use your flat fields, they must first have a dark frame subtracted. Although this may appear to be unimportant with such brightly lit and short exposures, there is the

'bias offset' of the camera in each image and this can produce an error in the final correction. As we are mainly interested in the bias, any very short exposure dark frame will give a good result. The dark subtracted images should then be averaged together before use.

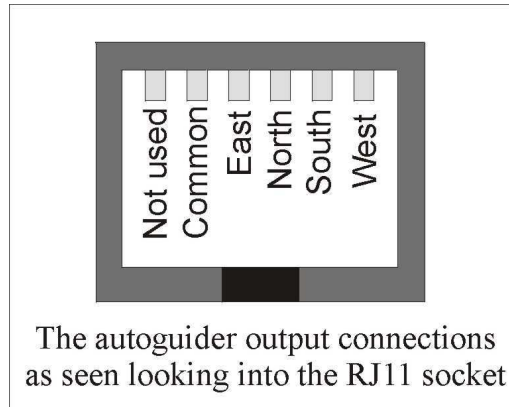
After the above procedures have been executed, the flat field will be ready for use. Load up your image for processing, subtract the dark frame and then select 'Apply flat field' in the 'Merge' menu. The result should be an image with very few signs of the original artefacts and you can then process it in the normal way.

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### **The SXV-M8C accessory ports**



The SXV-M8C is provided with two ports for use with accessories. The Autoguider output port is a 6 way RJ11 socket, which is compatible with the standard autoguider input of most telescope mounts. It provides 4 active-low opto-isolator outputs and a common return line, capable of sinking a minimum of 5mA per output. This socket may be used for telescope control if the SXV-M8C is employed as an autoguider, but is primarily intended to be the control output for the optional add-on autoguider camera head, available for use with the SXV-M8C.



The high density parallel port socket provides both control and power for the add-on autoguider, but also includes a pair of serial ports for use with other devices.

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### **Camera maintenance:**

Very little maintenance is needed to keep the SXV-M8C in excellent operating order, however two problems, which are common to all CCD equipment, might show up on occasion. These are dust and condensation.

#### **Removing Dust:**

1) Dust can be deposited on either the optical window (not a big problem to cure), or on the CCD faceplate (difficult to eliminate entirely). When small particles collect on the window they may not be noticed at all on deep sky (small F ratio) images, as they will be very much out of focus. However, if a powerful contrast boost of the image is carried out, they may well begin to show as the shadow 'Do-nuts' mentioned earlier. Images taken with a large F ratio optical system are more likely to be affected by such dirt, owing to the smaller and sharper shadows that they cast. There is no great difficulty in removing such particles on the outside surface by the careful use of a lens cleaning cloth or 'air duster' and so you should have little trouble with this aspect of maintenance. Dust on the CCD faceplate is a much greater nuisance, as it casts very sharply defined and dark shadows and it entails dismantling the camera to get rid of it! To clean the CCD you will need a good quality lens cloth (no silicone) or tissues and some high-grade isopropyl alcohol. A very suitable cloth is the 'Micro-Fibre' type marketed by PENTAX etc., and suitable alcohol is available from Tandy (Radio Shack) etc. as tape head cleaning fluid. A bright light and a strong watchmakers eyeglass will also be found to be essential.

#### **Procedure:**

- 1) Disconnect the lead from the camera head and remove it from the telescope. Place it on a table with the optical window facing downward.
- 2) Remove the two M3 screws from the camera back plate and ease the plate out of the camera body. Unplug the power lead from the camera PCB.
- 3) Withdraw the body cylinder and unscrew the two long spacer pillars from the heat sink plate assembly.

- 4) The entire camera electronic assembly can now be lifted away from the camera front barrel and the CCD will be readily accessible. Note that a layer of white heat-sink compound is applied to the periphery of the heat sink disc and this should be left undisturbed by subsequent operations.
- 5) You can now closely examine the CCD faceplate under the spotlight using the watchmaker's glass when any dust motes will show clearly. If there is only an odd particle or two and the CCD is otherwise clean, carefully brush away the dust with a corner of your lens cloth. A smeared or very dusty CCD will need a few drops of alcohol to clean thoroughly and you may have to make several attempts before the surface is free of contamination. One gentle wipe from one end to the other, with no return stroke, will be found to be the most effective action. DO NOT rub vigorously and be very careful to avoid scratching the window.
- 6) Before re-assembly, make certain that the inside surface of the front window is also clean, and then carefully replace the camera front barrel and screw it into place. (If the heat sink seal is disturbed, renew it with fresh compound before reassembling).
- 7) Replace all the camera parts in reverse order and the job is done.

### **Dealing with condensation:**

The SXV-M8C is designed to avoid condensation by minimising the volume of air trapped within the CCD cavity and by preventing moisture ingress. This normally works very well, but storage of the camera in a humid location can lead to the trapped air becoming moist by diffusion through the optical window mounting thread etc. and can result in condensation on the CCD window. If this becomes a problem, try storing the camera in a warm, dry place, or in a plastic lunch box containing a sachet of silica gel desiccant.

***N.B. DO NOT leave the camera switched on for long periods between uses. The cold CCD will collect ice by slow diffusion through any small leaks and this will become corrosive water on the cooler and CCD pins when the power is removed. If substantial amounts of moisture are seen, dismantle the camera and dry it thoroughly.***

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### **Alternative Software**

Although we hope that you will be satisfied with our 'SXV\_M8C\_USB' software, other companies are offering alternative programs with more powerful processing functions. The most active and successful of these is 'AstroArt' by MSB software. You can purchase AstroArt from many dealers Worldwide and more information may be obtained from their web site at <http://www.msb-astroart.com>

'Maxim DL' is another popular choice and you can find out more by visiting <http://www.cyanogen.com>

I particularly like the colour synthesiser in Maxim DL7.

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### **Some details of the camera and CCD characteristics**

**CCD type:** Sony ICX406AQ SuperHAD interline imager with RGBG Bayer colour filter matrix.

**CCD size:** Active area 7.225 x 5.375mm

**CCD pixels:** 2312 x 1720 pixel array. Each pixel is 3.125 x 3.125µm

**Well depth:** Full res. mode approx. 10,000e.

**Mean visual QE:** Approx. 25% effective, 60% for pixels at peak response

**Useful spectral response:** 360nm – 1100nm

**Readout noise:** Approx. 5e RMS typical, 10e max.

**Back focal distance:** The CCD is approximately 17.5mm from the barrel front.

**Camera size:** 51mm diameter x 100mm long

### **Dear Observer,**

Thank you for purchasing a Starlight Xpress CCD Imaging System. We are confident that you will gain much satisfaction from this equipment, but please read carefully the accompanying instruction manual to ensure that you achieve the best performance that is capable of providing.

As with most sophisticated equipment a certain amount of routine maintenance is necessary to keep the equipment operating at its optimum performance. The maintenance has been kept to a minimum, and is fully described in the manual.

In the unfortunate instance when the equipment does not perform as expected might we recommend that you first study the fault finding information supplied. If this does not remedy the problem, then contact Starlight Xpress for further advice. Our message board service on the Starlight Xpress web site will often provide solutions to any problems.

The equipment is covered by a 12-month guarantee covering faulty design, material or workmanship in addition to any statutory Consumer Rights of Purchasers.

### **CONDITIONS OF GUARANTEE**

- 1) The equipment shall only be used for normal purposes described in the standard operating instructions, and within the relevant safety standards of the country where the equipment is used.
- 2) Repairs under guarantee will be free of charge providing proof of purchase is produced, and that the equipment is returned to the Service Agent at the Purchaser's expense and risk, and that the equipment proves to be defective.
- 3) The guarantee shall not apply to equipment damaged by fire, accident, wear and tear, misuse, unauthorised repairs, or modified in any way whatsoever, or damage suffered in transit to or from the Purchaser.
- 4) The Purchaser's sole and exclusive rights under this guarantee is for repair, or at our discretion the replacement of the equipment or any part thereof, and no remedy to consequential loss or damage whatsoever.
- 5) This guarantee shall not apply to components that have a naturally limited life.
- 6) Starlight Xpress's decision in all matters is final, and any faulty component which has been replaced will become the property of Starlight Xpress Ltd.

For further info. or advice, please call:

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